PATHOGENS, EXCESS NUTRIENTS, AND TOXIC CHEMICALS

Poor water quality can also be caused by disease producing pathogens, excess nutrients and toxic chemicals.

Pathogenic bacteria, viruses or protozoa may be found in raw or untreated sewage and animal waste. When water is contaminated with these pathogens it can cause the spread of intestinal diseases causing gas, cramping, and diarrhea (Illinois Cooperative Extension Service; The Watercourse and Council for Environmental Education, 1995a).

Nutrients such as nitrate-nitrogen occur naturally in water from organic waste and is essential for the growth of aquatic plants. However, high levels of nutrients causes rapid growth of algae or algae blooms. When the algae die and decay, dissolved oxygen depletion occurs, killing off aquatic life (Kentucky Water Watch Program, 1993; Wisconsin Department of Natural Resources, 1989).

The sources of pathogens and excess nutrients in Kentucky waterways include:

- misapplication of fertilizers used in crop production, reforestation, and lawn care
- homeowners discharging waste directly into waterways through illegal straight pipes
- malfunctioning septic systems
- feedlot runoff
- livestock in waterways
- overflow from sewage treatment plants
- municipal and industrial wastewater

Various actions can be taken to prevent these substances from entering the waterways including:

- using the correct amount of fertilizer
- separating crop fields and reforestation areas from waterways or sinkholes with buffer zones
- applying fertilizer carefully, avoiding sidewalks, gutters and storm drains
- avoiding the application of fertilizer before a predicted heavy rainfall
- constructing lined livestock waste storage ponds or lagoons, holding tanks, or stack pads
- fencing livestock out of the waterways
- maintaining septic systems properly
- using alternate treatment for household waste such as peat biofilters, composting toilets, sand filtration systems, constructed wetlands, and slow rate spray drip disposal systems

(Janowicz, et. al., 1991; Mississippi Department of Environmental Quality, 1993; New Jersey Department of Environmental Protection, 1987; Kentucky Division of Conservation and Division of Water, 1993; Deaton and Nichols)

Toxic chemicals include pesticides such as herbicides, insecticides, fungicides, and rodenticides (Wisconsin Department of Natural Resources, 1989). Insecticides contain chemicals such as chloropyrifos which is used to kill a wide variety of insects and is highly toxic to freshwater fish and aquatic invertebrates. Herbicides may contain 2,4-D, metolachlor, alachlor, and atrazine which may be moderately or highly toxic to fish and other wildlife.

Proper management of pesticides reduce potential contamination of water resources, including:

- prompt clean-up of chemical spills
- correct application of pesticides

- encouraging pest-eating insects
- separating crop fields and reforestation areas from waterways or sinkholes with buffer zones
- applying lawn and garden chemicals carefully, avoiding sidewalks, gutters and storm drains
- avoiding the application of agricultural chemicals before a predicted heavy rainfall

(Janowicz, et. al., 1991; Mississippi Department of Environmental Quality, 1993; New Jersey Department of Environmental Protection, 1987; Kentucky Division of Conservation and Division of Water, 1993).

Kentucky industrial facilities reported generating 585.8 million pounds of toxic chemical wastes such as lead, mercury, and cadmium. The major industries producing this waste include the makers of:

- chemicals
- primary and fabricated metals
- paper/ allied products
- publishing/printing
- rubber/plastic
- transportation equipment

Most of these wastes are managed on site by the industries thorough recycling and treatment. However, 36.2 million pounds of waste were reported released to Kentucky's environment in 1994, even though toxic releases to the air have declined 24 percent and to water 71 percent since 1988 (Kentucky Environmental Quality Commission, 1996).

The following activities illustrate the effects of pollution from these sources.

HOW MANY FISH CAN LIVE IN POLLUTED WATER?

GRADES: 4-8
SUBJECT: Math, Science
SKILLS: Analyzing, computing, comprehending, discussing, evaluating
DURATION: 1 hour
SETTING: Outdoors or indoors
KERA ACADEMIC EXPECTATIONS: 1.4, 1.5, 2.2, 2.3, 2.8, 6.1, 6.3

OBJECTIVE:
To gain an understanding of how pollution can affect aquatic life.

METHOD:
Determine the percent composition of food items and toxic chemicals in an animal's diet.

MATERIALS NEEDED:

- Five colors of construction paper, each color cut into 30 - 2 inch squares
- Envelope for each participant
- Drinking straw for each participant
- Masking tape
- Paper and pencils
- Large paper tablet or poster
- Felt-tipped marker

PROCEDURE:

- Put a piece of tape, sticky side out, on one end of each straw.
- Scatter all but one of the five colors of paper pieces over a **large** open area (indoors if windy or rainy, etc.). Do not tell what each color represents at this time.
- Each participant gets an envelope and a straw, then form a line on either side of the paper pieces.
- Participants are largemouth bass that will **slowly** swim (crawl) to food source (paper pieces) and pick it up with their mouths (straws) and put it in their stomachs (envelope). Some fish are crippled or sick (crawl with one leg or arm in air).
- When all the paper has been picked up (consumed), each participant calculates the composition of each diet item:

  $$\frac{\text{\# of pieces of one color}}{\text{total \# of pieces collected}} \times 100 = \text{Composition}$$

- Explain that the four colors of paper represent:
  color 1 - freshwater shrimp
  color 2 - aquatic insects
  color 3 - crustaceans (small crayfish, etc.)
  color 4 - fish fry
- Estimates of percentage of composition of each prey item for the total diet of a largemouth bass includes: aquatic insects - 64%, freshwater shrimp - 25%, crustaceans - 8%, fish fry - 3%.
- Make a chart showing how participants' diet composition compares with total diet listed above.
- Play the game again with all five colors, do not tell what the fifth color represents at this time.
- When all the calculations have been made, explain that the fifth color represents a pesticide. Each piece equals 1 part per billion and starts to affect wildlife at 3 parts per billion.

EVALUATION:
This activity demonstrates what one species of fish needs to survive and what can happen to the population when a pollutant enters the environment.

- In round 1, how many fish had a diet composition comparable to the total diet for largemouth bass?
- How many did not? What will happen to these fish?
- Compare the first round diets to the second round diets. Are there any significant differences? Why?
- How many fish consumed pesticide?
- How would the pesticide get into their diet? (absorbed by algae, algae eaten by prey, prey eaten by largemouth bass)
- What will happen to the fish that consumed more than 3 parts per billion of pesticide?
- Compare the survival rates in the first round to the second round. Are there any significant differences? Why?

(adapted from Meador)

OTHER RESOURCES

GRADES:

4-8 The Watercourse and the Council for Environmental Education, 1995, No Bellyachers: Project WET, pp. 85-88.
Play a game of tag to show how pathogens are spread by water.

6-8 The Watercourse and the Council for Environmental Education, 1995, Poison Pump: Project WET, pp. 93-98.
Trace the source of contagious diseases.

6-A The Watercourse and the Council for Environmental Education, 1995, A Grave Mistake: Project WET, pp. 311-315.
Identify potential groundwater pollution.

7-A Western Kentucky University, TVA, and Kentucky Natural Resources and Environmental Protection Cabinet, 1992, Rural Water: Waste - A Hidden Resource in Kentucky, p. 24-39.
Build a model septic tank, see what happens when it fails.

Western Regional Environmental Council, 1987, The Glass Menagerie: AQUATIC Project WILD, pp. 121-124.
Measure the effect of nutrient loading on artificial habitats.

SILTATION

Each year tons of soil are eroded from lands that are left bare. Keeping the soil on the land not only keeps the land productive but also reduces the effect of siltation in surface water.

Soil erosion is the removal and loss of soil by ice, gravity, wind, or, most often, water. Erosion by water starts as splash erosion when the impact and splash of falling raindrops breaks down dirt clods and loosens soil particles. Sheet erosion follows, as these small loosened particles are picked up and carried away by surface runoff. As erosion progresses larger particles such as sand and rock fragments may be left behind perched on pedestals of soil. Rills and gullies form as soon as the surface flow establishes a path to nearby waterways.

Siltation of waterways occurs as the soil particles fill in the channel, cutting off light and reducing oxygen levels, which is detrimental to plants and animals (Soil and Water Conservation Service, 1986; Soil Conservation Service, 1994; Kentucky Water Watch Program, 1993).

Any bare soil (without plant cover) is a potential source of pollution every time it rains. The main causes of siltation are:

- land clearing and grading activities on construction, mining, and logging sites
- agricultural practices that leave the fields bare
- streamside erosion caused by livestock
- stream alterations such as channelization and dredging
- high-velocity surface runoff

To minimize soil loss, farmers use various soil conservation techniques such as:

- rotating crops with different growing seasons and nutrient needs in the same field to enrich the soil and keep it covered year round
- using no-till planting, one of the most cost-effective practices, to reduce soil loss to as little as one-half ton per acre
- fencing livestock out of waterways to cut down on streamside erosion
- adding mulch to small gardens

(Soil and Water Conservation Service, 1986, Kentucky Division of Conservation and Division of Water, 1993)

The development of a water management, erosion, and sediment control plan is needed on constructions sites before any activity begins. This includes:

- working with the existing topography to minimize grading
- grading to gentler slopes to reduce the velocity of surface runoff
- integrating surface and stormwater drainage systems
- retaining existing vegetation as much as possible
- seeding temporary vegetation on bare areas
- strategically placing sedimentation fencing, hay bales, and sedimentation ponds

(Kentucky Division of Conservation and Division of Water, 1994)

Soil erosion occurs in logging areas due to road building, harvesting, and site preparation for reforestation. The effects can be minimized by:

- avoiding wet and unstable areas
- restricting activities to the dry season
- leaving a buffer zone next to streams and sinkholes
- constructing roads across the slope of the land
- keeping stream crossings to a minimum
- planting a ground cover if the area is going to be exposed for a long time
- planning for rapid site reforestation
- using low impact site preparation methods for tree planting
- using equipment no larger than necessary

(Silviculture Non-Point Task Force, 1992; Adams, 1993)

Strip mines contribute most of the siltation to streams in mining areas. Best management practices include:

- constructing water diversions and sediment ponds
- constructing roads across the slope of the land
- removing and storing top soil in a protected area
- backfilling and grading with stored top soil
- grading to gentler slopes to reduce the velocity of surface runoff
- reseeding to reclaim the area (Barnhisel, and Hower, 1996)

Buffer zones should be constructed or left between bare ground and waterways or sinkholes in any land disturbance activity. Also, retaining natural wetland sites reduces the velocity of floodwater and permits the deposition of the sediment load within the wetland, minimizing downstream streambank erosion. In some areas where the streambank has been extensively eroded, trained professionals may need to be called in for restoration measures.

The following activities illustrate the effects of siltation on water quality.

MAKE SPLASH BOARDS TO STUDY SPLASH EROSION

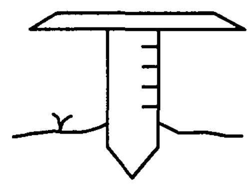
GRADES: 4-A*
SUBJECT: Science, Math
SKILLS: Comparing, experimenting, interpreting, measuring, observing, small group work
DURATION: 30 minutes to set up, 1 hour if sprinkling instead of waiting for rainfall
SETTING: Outdoors, suitable for use in outdoor classroom
KERA ACADEMIC EXPECTATIONS: 1.3, 1.8, 2.1, 2.2, 2.3, 2.10, 4.2, 5.3, 6.2

OBJECTIVE: To observe how soil particles are dislodged by rainfall.

METHOD: Measure the amount and height of splashed soil after a rainfall.

MATERIALS NEEDED PER GROUP:

- 1x4 board about 3 feet long with one end sharpened
- Black permanent marker
- Yard stick
- Tacks
- Foil pie plate
- Hammer



PROCEDURE:

- Select several sites with varying amounts of grass or other cover; include a bare spot.
- Divide class into groups and assign each group a site.
- Above sharpened end, mark lines on both sides of boards at one-foot intervals with smaller marks every 2 inches.
- With hammer, pound boards into ground at selected sites.
- Attach each pie plate to top of board with tacks to prevent splashed soil from being washed off.
- After a rain, check the boards to see how much soil has splashed onto them. Record the heights. Or sprinkle with hose if rain is not imminent.
- Wipe boards clean before repeating activity.

EVALUATION:
This activity demonstrates how splash erosion can cause soil loss on unprotected ground.

- Which site had the most splash erosion? Why?
- Which site had the least splash erosion? Why?
- What happens when the soil particles are loosened by the rain? (Particles are carried off by surface water runoff)

EXTENSIONS:

- Record how much is splashed during different rainfalls: gentle rain, downpour, etc.
- Record the heights of any soil pedestals capped by rock fragments or pebbles. Determine the volume of soil removed by multiplying the pedestal height times the area of a square around the board.

* For Grades K-3 observe the sides of buildings and record how high soil is splashed on them.
(Adapted from Soil and Water Conservation Service, 1986)

HOW DO CROP COVER, MULCHING, AND CONTOUR PLOWING AFFECT SOIL LOSS?

GRADES: 4-A*
SUBJECT: Science
SKILLS: Comparing, experimenting, interpreting, observing, small group work, visualizing
DURATION: 30 minutes
SETTING: Outdoors
KERA ACADEMIC EXPECTATIONS: 1.3, 2.2, 2.4, 4.2, 5.3, 6.2

OBJECTIVE:
To gain an understanding of how different soil conservation practices act as deterrents to soil erosion.

METHOD:
Demonstration of the difference in the amount of soil erosion between vegetated, mulched, and bare soil, and contour vs. non-contour plowing.

MATERIALS NEEDED PER GROUP:
- Rectangular pan (aluminum cake pan)
- Sprinkling can or sprinkler hose, or wait for rain
- Enough soil to fill the pan
- A piece of sod to fit the pan for group 1
- Mulch for group 2

PROCEDURE:
- Divide class into 5 groups; give each group the materials needed.
- Group 1 fills a pan with soil and puts the piece of sod on top (trim grass to 1 inch in height).
- Group 2 fills a pan with soil and tops it with mulch.
- Group 3 fills a pan with soil.
- Group 4 fills a pan with soil and makes furrows down the length of the pan.
- Group 5 fills a pan with soil and makes furrows across the width of the pan.
- Raise one end of each pan.
- Sprinkle all pans with the same amount of water, at the same time and rate, and from the same height or leave outside and observe after a rain.

EVALUATION:
This activity demonstrates the effect of erosion on bare soil and the effectiveness of different conservation practices.
- Which box experienced the most erosion?
- Which pan illustrated the best method for soil conservation?

* For Grades K-3 this activity can be conducted as a teacher demonstration.

(Adapted from Soil and Water Conservation Service, 1986)

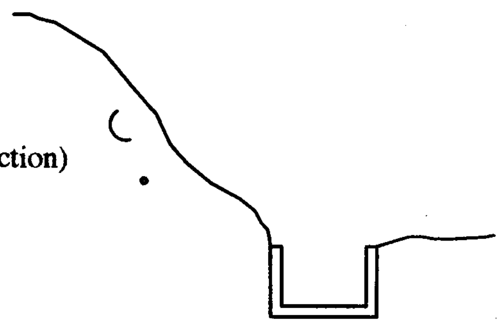
EROSION CONTROL DEMONSTRATION AREA

GRADES: 4-A*
SUBJECT: Science, Math
SKILLS: Analyzing, comparing, evaluating, experimenting, measuring, observing
DURATION: Several class periods to construct. Monitor at periodic intervals.
SETTING: Outdoors, suitable for use in outdoor classroom
KERA ACADEMIC EXPECTATIONS: 1.3, 1.8, 2.1, 2.2, 2.3, 2.4, 2.10, 5.1, 5.3, 6.2, 6.3

OBJECTIVE: To observe and measure how surface runoff contributes to soil erosion.

METHOD: Construct a demonstration area where soil loss can be measured in three different environments.

MATERIALS NEEDED:



- Flat-edged shovel for sod removal
- Rip rap (large stones)
- 3 Sections of roof gutter (length equal to width of each site section)
- 6 gutter ends
- Yard stick or tape measure

PROCEDURE:

- Be sure to ask permission first!
- Select a site on school grounds with moderate slope, 3 feet wide, and about 6 feet long (measurements can be adjusted to fit local conditions). Or create one by mounding and compacting earth into a hill about 3-4 feet high.
- Divide site into 3 equal sections; bottom of section should be at bottom of hill.
- Strip all grass and vegetation from two sections; leave only bare soil exposed.
- Site 1 - is original vegetation.
- Site 2 - cover with rip rap.
- Site 3 - leave bare.
- Dig a trench at bottom of each section for the rain gutter. Should be deep enough that gutter is level with ground surface.
- Place ends on gutter pieces and place in trench. Runoff should be able to drain from the section down into the gutter.
- Measure the volume of soil collected in each gutter section after a good rain.
- Clean out gutters before repeating activity.

EVALUATION: This activity demonstrates the effect of erosion on various land surfaces.

- Which section lost the most amount of soil? Why?
- Which section lost the least amount of soil? Why?

* For Grades K-3 conduct the activity after erosion area has been constructed

(Adapted from Louisiana Department of Agriculture and Forestry, 1993)

OTHER RESOURCES

GRADES:

K-5 Sport Fishing Institute, 1955, Conservation Chart and Text: Washington, D. C., 1988 edition, 15 pp. plus chart.
Soil conservation story of two valleys.